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SPECIFICATION, CLAIMS AND ABSTRACT

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CATHODE RAY TUBE FOR ACHIEVING SMALL ELECTRON BEAM LANDING DEVIATION

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to a cathode ray tube. More particularly, the present invention relates to an internal magnetic shield with a shape designed for correcting the trajectory of electron beams deviated by external magnetic forces typified by terrestrial magnetism.

(2) Description of Related Art

FIG. 11 shows a conventional cathode ray tube (hereinafter referred to as CRT) used as a TV display or a monitor for a personal computer. An electron beam 111 emitted from an electron gun is deflected vertically or horizontally by a deflection coil 112 to scan the whole screen to reproduce an image. In this process, what is called landing deviation may happen. That is to say, the electron beam 111 may deviate from an intended trajectory and may not reach an aimed position when it receives an external magnetic field such as terrestrial magnetism from a direction perpendicular to the direction of the trajectory of the beam. In FIG. 11, the center line indicates an originally intended trajectory, and the center line the deviated trajectory (this example is exaggerated a little). To prevent the landing deviation, an internal magnetic shield 115 is disposed to surround

a path of the electron beam inside the CRT (in this case, inside a funnel). It should be noted here that in the CRT, typically a raster scan method is used. In the raster scan method, the deflection coil controls the amount of deflection of the electron beam so that the electron beam horizontally scans the screen (toward the front or back in FIG. 11) and scans vertically (in the direction of Y in FIG. 11), the horizontal and vertical scans forming a raster.

The internal magnetic shield 115 cannot shield the CRT completely from external magnetic fields. Therefore, in reality, the internal magnetic shield 115 (a) shields the CRT from external magnetic fields to some extent, (b) changes the direction of the magnetic force so as not to affect the election beam, or (c) corrects the force the electron beam receives at a certain position.

Except for some special cases, an external magnetic field that affects the electron beam is the terrestrial magnetism. The terrestrial magnetism is divided into a horizontal component (a horizontal component of a vector relative to the viewing angle of the screen) and a vertical component (a vertical component of a vector relative to the viewing angle of the screen). As is well known, the vertical component changes the landing uniformly over the whole screen. The landing deviation caused by the vertical component are not regarded as a problem since the phosphor screen position is corrected using a correction lens or the like when the

phosphor screen is formed.

In contrast, a horizontal magnetic field changes its direction depending on the relative positions of the CRT and the magnetic field. Typically, as shown in FIG. 12, a horizontal magnetic field 120 is divided into a CRT tube-axis direction 121 and a lateral direction 122. Here, the space through which the electron beam passes is conical, expanding as the electron beam proceeds. The axis of the conical space through which the electron beam passes is called tube axis.

To achieve a shield from the terrestrial magnetism, it is necessary to consider the magnetic characteristics of a lateral magnetic field and a tube-axis-direction magnetic field which are components of a horizontal force of the terrestrial magnetism.

It is possible to apply from outside a magnetic field force equivalent to the terrestrial magnetism force or stronger, measure the electron beam landing deviation on the phosphor screen caused by the application of the force, and evaluate the magnetic characteristics in the CRT. FIG. 13 shows the measuring points: four corner points; and two center points (hereinafter referred to as NS points) of upper and lower portions. Here, important characteristics are as follows:

(1) characteristics at corner points (hereinafter called lateral characteristics) when a lateral magnetic field is applied; and

(2) characteristics at NS points (hereinafter called NS characteristics) when a tube-axis-direction magnetic field is

applied.

FIG. 14 shows the shape of a conventional, typical internal magnetic shield 115. As shown in FIG. 14, the internal magnetic shield 115 is a pyramid including two long sides 141 opposite to each other and two short sides 142 opposite to each other, where an opening 143 is formed at the top.

Recently, CRTs with a large-screen or a flat-screen are becoming mainstream. A shadow mask used in a flat-screen CRT is typically manufactured by applying a tension. That is to say, in this method, the shadow mask is manufactured by spanning a plurality of tensed wires between a pair of opposite sides of a frame.

In CRTs with such a conventional internal magnetic shield, the landing deviation caused by the terrestrial magnetism tends to increase. This is because with the tensed shadow mask, the magnetic reluctance of the shadow mask increases and generates an undesired magnetic field in the vicinity of the shadow mask (Murai et al., SID2000DIGEST, pp582-585). For example, in conventional 25-inch CRTs, both lateral characteristics and NS characteristics are approximately 10 μm. However, after the shadow mask is tensed, the lateral characteristics become 30 μm and NS characteristics become 25 μm. That is to say, both characteristics deteriorate.

Up to now, there has been some attempts to improve the characteristics of the internal magnetic shield with the

construction shown in FIG. 14. For example, the top of the short sides 142 of the internal magnetic shield is cut to form a V-shaped cut 144 as shown in FIG. 14, and optimization is performed by changing the depth or width of the cut 144.

The characteristics more greatly change when the depth of the V-shaped cut is changed, than when the width or the like is changed. FIG. 15 shows relation between the landing deviation and the depth of the V-shaped cut. As shown in FIG. 15, the deeper the cut is, the more improved the characteristics is. However, the NS characteristics rarely change. When the depth of the V-shaped cut is changed from 0mm to 150mm, the lateral characteristics change by 10μm, but the NS characteristics rarely change.

By the optimization of the V-shaped cut, the landing deviation caused by an external magnetic field equivalent to the terrestrial magnetism has been improved as follows:
(lateral characteristics, NS characteristics) = (20μm, 23μm).
However, improvement of both characteristics have not been achieved yet.

Also, the lateral characteristics and NS characteristics are in a tradeoff relationship in which the change rates of the characteristics are almost the same and the directions are reversed. This renders it more difficult to improve both the characteristics at the same time.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a cathode ray tube that decreases the electron beam landing deviation caused by an external magnetic field such as the terrestrial magnetism and prevents the color on the screen from blurring or fading.

To fulfill the above object, the present invention is characterized by the magnetic field distribution inside the internal magnetic shield in the vicinity of the deflection coil and by the magnetic field distribution in the vicinity of the shadow mask.

To fulfill the above object, the magnetic field distribution on the trajectory of electron beams for displaying the circumferential portion of an image on the CRT screen is important. This portion corresponds to upper and lower areas each occupying approximately 20% of the area of a plane at the entrance of the internal magnetic shield.

It has been found that to improve the NS characteristics, the distribution of the vertical magnetic field (represented by "By". Here, the term "vertical" indicates a direction along the vertical scanning direction) should be modified. More specifically, as shown in FIG. 16, a prominent effect is produced when the By component in the vicinity of the deflection coil and the By component in the vicinity of the shadow mask are oriented in opposite directions (plus and minus

directions). Note that in FIG. 16, the magnetic field By is represented by a relative value. With this construction, it is possible to deviate the trajectory of an electron beam at the entrance of the internal magnetic shield to a direction opposite to a direction of deviation of the trajectory generated in the vicinity of the mask, offsetting a force that is applied to the electron beam perpendicular to the electron beam trajectory, and decrease the landing deviation of the electron beam.

To orient the By component in the vicinity of the deflection coil to the minus direction, the inventors improved the internal magnetic shield as follows.

(1) The inventors devised the shape of the internal magnetic shield so that the amount of magnetic flux absorbed at both ends (in the embodiment, the long sides) in the vertical scanning direction at the entrance of the electron beam in the vicinity of the deflection coil is larger than that at both ends (in the embodiment, the short sides) in the horizontal scanning direction.

(2) The inventors changed the effective permeability so that the amount of magnetic flux absorbed at both ends in the vertical scanning direction at the entrance of the electron beam in the vicinity of the deflection coil is larger than that at both ends in the horizontal scanning direction.

The effective permeability can be changed, for example, by forming both ends in the vertical scanning direction at the

entrance of the electron beam in the vicinity of the deflection coil using a material having substantially high effective permeability, and forming both ends in the horizontal scanning direction using a material having substantially low effective permeability.

As described above, the present invention decreases the electron beam landing deviation by changing the magnetic field distribution inside the internal magnetic shield in the vicinity of the deflection coil and the magnetic field distribution in the vicinity of the shadow mask.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects, advantages and features of the invention will become apparent from the following description thereof taken in conjunction with the accompanying drawings which illustrate a specific embodiment of the invention. In the drawings:

FIG. 1 is a sectional view of a CRT in the embodiment of the present invention;

FIG. 2 shows the internal structure of the CRT focusing on a main portion related to the present invention, and is a perspective view of the internal magnetic shield 30 and a mask frame 40 which are to be assembled;

FIG. 3 shows measurement results of electron beam landing deviation in correspondence to the difference between the

heights H1 and H2;

FIG. 4 shows relation between the width W1 of the cuts 35 and the electron beam landing deviation;

FIG. 5 shows relation between the depth of the cuts 35 and the electron beam landing deviation;

FIGs. 6A and 6B are perspective views showing the construction of the internal magnetic shield in variations of the embodiment;

FIGs. 7A and 7B are plan views of a short side constituting the internal magnetic shield in variations of the embodiment;

FIG. 8 shows relation between the length L of the cuts 54 and the electron beam landing deviation;

FIGs. 9A and 9B are perspective views showing the construction of the internal magnetic shield in variations of the embodiment;

FIG. 10 is a perspective view showing the construction of the internal magnetic shield in a variation of the embodiment;

FIG. 11 is a sectional view of a conventional CRT;

FIG. 12 shows components of a vector in a horizontal magnetic field generated in the CRT;

FIG. 13 shows the measuring points of the landing deviation on a CRT screen;

FIG. 14 is a perspective view showing the construction

of the internal magnetic shield for a conventional CRT;

FIG. 15 shows relation between the electron beam landing deviation and the depth of the V-shaped cut of the internal magnetic shield for the conventional CRT; and

FIG. 16 shows the distribution of a magnetic field generated in the vertical direction in the CRT of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following are description of the present invention through specific embodiments thereof by way of referring to the drawings.

Embodiment

The CRT of the present invention will be described in detail.

Construction of CRT and Internal Magnetic Shield

FIG. 1 is a sectional view of the embodiment of the present invention.

The CRT shown in FIG. 1 is a 25-inch, flat-screen (front portion of the face plate is flat) CRT and the shadow mask is a wire-spanned-frame type.

More specifically, the CRT mainly includes: a face plate 10 whose front portion is flat; a funnel unit 15 including an internal magnetic shield 30; a neck unit 20; and an electron gun 25 inserted in the neck unit 20.

Phosphor units 11 for various colors are formed inside the front portion of the face plate 10. Also, a deflection coil 16 is attached to the CRT, surrounding an end of the funnel 15 opposite to the face plate 10.

FIG. 2 shows the internal structure of the CRT focusing on a main portion related to the present invention, and is a perspective view of the internal magnetic shield 30 and a mask frame 40 which are to be assembled.

As shown in FIG. 2, the internal magnetic shield 30 is a pyramid including two opposite long sides 31 and two opposite short sides 32, having an opening 33 at the top.

A rectangular extension 34 is formed at a horizontal center of an upper end (in the vicinity of the deflection coil 16) of each long side 31.

Cuts 35 are formed on both sides of the extension 34 at upper corners of each long side 31.

Cuts 36 are formed at upper corners of each short side 32, in align with the cuts 35.

It is defined that a height H1 of an upper end 34A of the extension 34 measured from the bottom of the cut 35 is higher than a height H2 of an upper end 32A of the short side 32 measured from the bottom of the cut 36. Note that the bottoms of the cuts 35 and 36 have the same height.

The mask frame 40 is composed of a pair of spanning units 41 and a pair of U-shaped holding units 42. The pair of U-

shaped holding units 42 are arranged opposite to each other. The pair of U-shaped holding units 42 are welded and fixed at two pairs of opposite ends of the pair of spanning units 41. A plurality of tensed wires are spanned between the pair of spanning units 41, the plurality of wires forming a shadow mask Ma. The plurality of wires are spanned at certain positions of the holding units 42 which are determined to hold the tension of the shadow mask Ma and to increase the strength of the frame in the direction of tension.

A lower end of the internal magnetic shield is fixed, by welding or the like, to a plane of the mask frame 40 which is opposite to a plane on which the shadow mask Ma is spanned.

Action and Effects of Internal Magnetic Shield

As described above, a rectangular extension is formed at a horizontal center of an upper end of each long side so as to be higher than the short sides. With this construction, the amount ($\phi 1$) of magnetic flux absorbed at both ends of the internal magnetic shield in the vicinity of the deflection coil in a vertical scanning direction is larger than the amount ($\phi 2$) of magnetic flux absorbed at both ends of the internal magnetic shield in a horizontal scanning direction ($\phi 1 > \phi 2$). In other words, the magnetic flux density (B1) at both ends of the internal magnetic shield in the vicinity of the deflection coil in a vertical scanning direction is higher than the magnetic flux density (B2) at both ends of the internal magnetic shield in a

horizontal scanning direction (B1>B2).

Also, in each long side, the amount of magnetic flux absorbed at the extension 34 is larger than that at the cuts 35. As a result, the density of magnetic flux absorbed at the extension 34 is higher than that in the vicinity of the cuts 35. That is to say, magnetic fields concentrate on the extension 34.

When the amount of absorbed magnetic flux and the magnetic flux density in the internal magnetic shield differ between the horizontal direction and the vertical direction as in the above case, the By component in the vicinity of the deflection coil and the By component in the vicinity of the shadow mask are oriented in opposite directions (plus and minus directions). With this construction, it is possible to deflect the trajectory of an electron beam in the vicinity of an entrance of the internal magnetic shield in an opposite direction to a direction in which the electron beam is to deviate in the vicinity of the mask. That is to say, a force an electron beam receives in the vertical direction is canceled out. As a result, the NS characteristics are effectively improved. That is to say, the landing deviation of electron beams are effectively improved in terms of the NS characteristics.

Also, since different amounts of absorbed magnetic flux are generated by setting the extension of the long sides higher than the short sides, the curvature (R1) of magnetic flux being absorbed at both ends of the internal magnetic shield in the

vicinity of the deflection coil in a vertical scanning direction is higher than the curvature (R2) of magnetic flux being absorbed at both ends of the internal magnetic shield in a horizontal scanning direction (R1>R2).

Also, in each long side, the curvature of magnetic flux being absorbed at the extension 34 is higher than that at the cuts 35. This indicates that magnetic fields concentrate on the extension 34.

The reason why the curvature of magnetic flux differs at different areas as described above is considered to be that when an external magnetic field proceeding straight along the tube axis is absorbed in the vicinity of the entrance of the internal magnetic shield, the amount of magnetic flux absorbed at both ends in the vertical scanning direction is larger than that at both ends in the horizontal scanning direction, i.e., magnetic flux is absorbed more efficiently at both ends in the vertical scanning direction.

In normal times, the external magnetic field is absorbed in every area surrounding the electron beam passing area, in the vicinity of the entrance of the internal magnetic shield. In contrast, in the case of the present embodiment, since the extensions are formed on the long sides, the external magnetic field is absorbed more at the extensions, not uniformly in every area surrounding the electron beam passing area.

The above action of making a difference in the amount

of absorbing external magnetic fields (amount of absorbing magnetic flux) depends on the difference between the heights H1 and H2, and there is an optimum range of values for the difference in achieving the above action. It should be noted here that the height H1 should be determined so that the ends of the internal magnetic shield does not enter the space surrounded by the deflection coil. This is because this would interrupt the deflection control by the deflection coil.

FIG. 3 shows measurement results of electron beam landing deviation in correspondence to the difference between the heights H1 and H2 (while H2 if fixed to 2cm and 4cm, H1 is varied. W1=W2=3cm).

As shown in FIG. 3, regardless of whether H2 is 2cm or 4cm, the electron beam landing deviation shows a similar tendency. When H2 is 2cm, H1=2-4cm is the optimum range in which the landing deviation is the smallest.

The above action of making a difference in the amount of absorbing external magnetic fields (amount of absorbing magnetic flux) becomes more prominent by forming the cuts 35 and 36 at upper corners of the long and short sides 31 and 32. The reason for this is considered to be that by forming the cuts 35 and 36, the amount of magnetic flux absorbed at the areas where the cuts 35 and 36 are formed is reduced, and the magnetic flux is absorbed at the extensions more efficiently. There is also an optimum range of values for the size of the cuts in achieving the

above action.

FIG. 4 shows measurement results of electron beam landing deviation in correspondence to the varied widths W1 and W2 of the cuts when the depth of the cuts 35 and 36 is 2cm, where W1=W2.

Compared to the measurement results shown in FIG. 15 of electron beam landing deviation for the varied depth of the V-shaped cut formed in the short sides, it is understood from FIG. 4 that by forming the cuts at upper corners, the NS characteristics are improved, though the lateral characteristics are less improved. However, it is also found that both the V-shaped cut and the cuts at upper corners can be formed, as will be described later. It should be noted here that although the measurement results do not show, it is desirable that the width of a cut 35 at an upper corner of a long side is less than half of the length of the upper end of the long side.

As apparent from above, the present embodiment provides an excellent method for improving the NS characteristics when a type of tube to which the lateral characteristics do not matter much is used. Minute adjustments are made by varying the cut widths W1 and W2.

In the above description, it is presumed that the depth of the cuts is 2cm. However, similar effects are obtained by changing the depth of the cuts.

FIG. 5 shows measurement results of electron beam

landing deviation in correspondence to the varied depths of the cuts when the width of the cut in the short side is 3cm, and the width of the cut in the long side is 5cm.

Using the above-described internal magnetic shield, it is possible to form a magnetic field that offsets an external force such as terrestrial magnetism an electron beam receives before it reaches the phosphor screen. This weakens the received force, decreases the landing deviation, and prevents the color on the screen from blurring or fading. It is also possible to offset effects of external magnetic fields typified by the terrestrial magnetism and improve the NS characteristics.

Variations

(1) A V-shaped cut may be formed in each short side 32 at the opening 33 in the vicinity of the center of the deflection coil.

More specifically, V-shaped cuts as shown in FIGs. 6A and 6B are formed.

As shown in FIGs. 6A and 6B, the internal magnetic shield 60 is a pyramid including two opposite long sides 61 and two opposite short sides 62, where an opening 63 is formed in a direction along the axis of the pyramid, and a cut 64 is formed in each short side at the opening in the vicinity of the center of the deflection coil.

The cut 64 shown in FIG. 6A is a simple cut with one cut angle (θ1).

In contrast, the cut 64 shown in FIG. 6B has two cut

angles: a wide cut angle $\theta 2$; and a narrow cut angle $\theta 3$, and is home-plate-shaped.

(2) The bottom 64A of the cut 64 may be flat having a certain width as shown in FIG. 7A, or may be semicircular as shown in FIG. 7B, instead of a narrow angle.

FIG. 8 shows measurement results of electron beam landing deviation in correspondence to the varied width (represented by L in FIG. 6A) of the cut 64. As shown in FIG. 8, the NS characteristics and the lateral characteristics similarly change.

Accordingly, when L=30mm,

NS characteristics = 15μm

lateral characteristics = 10μm

(3) The extension may be a plurality of projections 91 as shown in FIGs. 9A and 9B.

The projections may be rectangular as shown in FIG. 9A, or semicircular as shown in FIG. 9B.

The center of the extension may be triangular having a cute angle, as shown in FIG. 10. With this construction, the magnetic flux is absorbed more effectively at this portion.

It should be noted here that in the drawings from 1 to 10, the magnetic shield and mask frame are drawn to be somewhat distant for the sake of helping the understanding.

It is presumed in the above embodiment that the present invention is achieved in a 25-inch CRT. However, the present

invention is applicable to CRTs of other screen sizes. The height of the extension or the width of the cut change in accordance with the size of the CRT or the environment in which the CRT is used. The electron beam landing deviation may be caused by a magnetic field generated by the deflection coil, as well as by an external magnetic field. The trajectory of an electron beam also changes in accordance with the characteristics of the deflection coil, regardless of the shape of the internal magnetic shield. Accordingly, an optimum internal magnetic shield is formed by adjusting the size of each component based on the characteristics of the deflection coil.

The present invention has been fully described by way of examples with reference to the accompanying drawings, it is to be noted that various changes and modifications will be apparent to those skilled in the art. Therefore, unless such changes and modifications depart from the scope of the present invention, they should be construed as being included therein.